SPECIAL REPORT 93-13

AD-A268 459

CRREL

Selection of Cool-Season Grasses for Revegetating Well-Drained Fill Materials

Antonio J. Palazzo

June 1993

Abstract

The objective of this study was to evaluate the performance and persistence of 11 cool-season grasses growing in well-drained fill materials. Grasses were evaluated over a four-year period and grown on fill material containing 11% gravel, 61% sand, 27% silt and 1% clay at the Franklin Falls Dam in Franklin, N.H. During the second season, half of each plot was refertilized. Visual observations of the sown grasses suggested that moisture stress was an important factor limiting growth. During the last two years of study, the most persistent species were Jamestown chewings fescue (*Festuca rubra* L. ssp. *commutata* Gaud.) and Canada bluegrass (*Poa compressa* L.). Refertilization helped to promote growth and increase persistence of all the sown species except for Jamestown chewings fescue. Three improved varieties of the grasses were not consistently more persistent than their common counterparts. This study demonstrates that there are major differences among cool-season grasses in their ability to tolerate well-drained, low-maintenance sites. When refertilized, varieties of tall fescue (*Festuca arundinacea* Schreb.) and Kentucky bluegrass (*Poa pratensis* L.) were more persistent, and a perennial ryegrass (*Lolium perenne* L.) provided rapid emergence.

For conversion of SI metric units to U.S./British customary units of measurement consult *Standard Practice for Use of the International System of Units (SI)*, ASTM Standard E380-89a, published by the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103.

This report is printed on paper that contains a minimum of 50% recycled material.

Special Report 93-13

US Army Corps of Engineers
Cold Regions Research & Engineering Laboratory

Selection of Cool-Season Grasses for Revegetating Well-Drained Fill Materials

Antonio J. Palazzo

June 1993

Accesion For		
NTIS CRA&I	X	
DTIC TAB	☐	
Unannounced	☐	
Justification		
By		
Distribution /		
Availability Codes		
Dist	Avail and / or Special	
A-1		

Prepared for
U.S. ARMY ENGINEERING AND HOUSING SUPPORT CENTER

PREFACE

This report was prepared by Antonio J. Palazzo, Research Agronomist, Geochemical Sciences Branch, Research Division, U.S. Army Cold Regions Research and Engineering Laboratory. Funding was provided by the Natural and Cultural Resources Division of the U.S. Army Engineering and Housing Support Center, Ft. Belvoir, Virginia, under the direction of Donald Bandel.

The author thanks John Graham, Charles Racine and Ronald Bailey for assistance in collecting and analyzing the data; James Ward, Odie La Rouche and John Porano for site establishment assistance; and David Cate, John Dickerson, Robert Duell, Giles Marion, Albert Page and Brian Pillsbury for technical reviews of the manuscript.

The contents of this report are not to be used for advertising or commercial purposes. Citation of brand names does not constitute an official endorsement or approval of the use of such commercial products.

Selection of Cool-Season Grasses for Revegetating Well-Drained Fill Materials

ANTONIO J. PALAZZO

INTRODUCTION

Cool-season grasses are widely recommended for revegetating low-maintenance sites in the northeast United States. Low-maintenance sites in cool, humid areas usually consist of large acreages along highways (Wakefield et al. 1974), sand and gravel borrow areas (USDA-SCS 1980), mined lands (Paone et al. 1978) and Army training lands. Evaluation of cool-season grasses for revegetating low-maintenance sites is necessary because these grasses were bred primarily for lawns and pastures, which typically have higher nutrient- and moisture-holding capacities than most low-maintenance sites.

Plants grown on fill materials low in fertility do not establish stands as well as when topsoil or other soil amendments are used (Wakefield et al. 1974, Hansen and Mitchel 1978, Palazzo et al. 1980). The frequent lack of establishment success has been attributed either to the plant's slow growth rate (Bradshaw and Chadwick 1980) or to soil deficiencies of nitrogen and phosphorus (Palazzo and Graham 1981). Fertilization of poor grass stands improves vegetative cover (Palazzo et al. 1980, Gaffney and Dickerson 1987) and may be necessary to maintain stands (Carlson et al. 1961). Gaffney and Dickerson (1987) related the poor performance of cool-season grasses at a number of sand and borrow pit sites to the percentage of fines in the soil; better performance of cool-season grasses was observed in soils containing greater than 20% fines.

Wakefield et al. (1974), who conducted long-term studies on roadside subsoils in Rhode Island, reported that the best-performing species were the fine-leaved fescues (*Festuca* sp.) and colonial bentgrass (*Agrostis tenuis* Sibth.). Tall fescue and timothy (*Phleum pratense* L.) had difficulty establishing a stand. Kentucky bluegrass, Canada bluegrass and perennial ryegrass did not persist. Similar observations have been made in Great Britain by Bradshaw and Chadwick (1980), who recommended red fescue (*Festuca rubra* L. ssp. *rubra*) and colonial bentgrass for revegetating sand heaps.

The objectives of this study were to evaluate 11 cool-season grasses for their persistence on fill material. The study will provide information needed for selecting plant species for well-drained, low-maintenance areas in cool, humid climates.

MATERIALS AND METHODS

The research site was located in a fill area of the Franklin Falls Dam in Franklin, N.H. A sandy fill (11% gravel, 61% sand, 27% silt and 1% clay) with a water-holding capacity of 20.8% (Gardner 1986) was used to construct the lower level of the dam. Chemical analysis of the soil (Liegel and Schulte 1977) indicated that the fill had a pH of 5.6 and had levels of available phosphorus (157 kg ha^{-1}) and exchangeable potassium (224 kg ha^{-1}) sufficient for grass growth.

Following grading, the site was disked to a depth of approximately 15 cm to smooth the soil surface. Fertilizer applied at a rate of 67 kg ha^{-1} each of nitrogen, P_2O_5 and K_2O was incorporated 5 cm deep prior to seeding. Seed of 11 grasses was broadcast and lightly raked into the fill material on 3 October 1985. Grasses and seeding rates (kg ha^{-1}) used were:

- Colonial bentgrass (*Agrostis tenuis* Sibth.): 90
- Rebel and K-31 tall fescues (*Festuca arundinacea* Schreb.): 179
- Common timothy (*Phleum pratense* L.): 134
- Common roughstalk bluegrass (*Poa trivialis* L.): 134
- Linn and Palmer perennial ryegrasses (*Lolium perenne* L.): 179

- Common and Nassau Kentucky bluegrasses (*Poa pratensis* L.): 134
- Jamestown chewings fescue (*Festuca rubra* L. ssp. *commutata* Gaud.): 179
- Common Canada bluegrass (*Poa compressa* L.): 134.

The site was rolled and mulched with straw at a rate of 2200 kg ha^{-1}. Plots (28.3 m^2) were arranged in a randomized split-plot design with four replicates. On 19 June 1986, half of each plot was refertilized at rates of 90 kg ha^{-1} each of nitrogen, P_2O_5 and K_2O. In August 1986, Rebel tall fescue, Palmer perennial ryegrass, Nassau Kentucky bluegrass and Jamestown chewings fescue were sampled for nutrient analysis from the fertilized and unfertilized plots (Martin and Matocha 1973).

Preliminary observations were made on 20 November 1985, 14 April 1986 and 12 May 1986 to evaluate species establishment. The percent soil cover of sown species was rated on 10 July 1986, 4 August 1987, 28 July 1988 and 27 July 1989, when most grasses were fully headed. Visual ratings used a numerical scale of 1 to 10, with 10 representing 100% vegetative cover.

Plant cover ratings for the individual grasses were subjected to an analysis of variance, as described by the statistical program MSTAT (Michigan State University 1987).

RESULTS

Early observations of the grasses showed that all species emerged well and that initial establishment was satisfactory (data not shown). The best early soil coverage was obtained with the two perennial ryegrass cultivars.

Data obtained 25 days following the 19 June 1986 refertilization of half of each experimental plot showed that Canada bluegrass, K-31 tall fescue, Nassau Kentucky bluegrass, common Kentucky bluegrass, Palmer perennial ryegrass, Linn perennial ryegrass and roughstalk bluegrass benefited appreciably from refertilization (Fig. 1). The other four grasses had higher ratings for vegetative cover but did not respond significantly to refertilization. The 1986 refertilization benefit carried over to 1987 and significantly enhanced the stands of Canada bluegrass, colonial bentgrass, K-31 tall fescue, Nassau Kentucky bluegrass and common Kentucky bluegrass. Mean values for five nutrient elements contained in four grass species showed that nutrients were not a limiting factor for plant growth in either fertility situation according to Martin and Matocha (1973). Mean levels of elements analyzed were: nitrogen, 1.96%; phosphorus, 0.29%; potassium, 2.39%; calcium, 0.41%; magnesium, 0.15%; and sulfur, 0.15%. Refertilization did, however, elicit a slight (but not statistically significant) increase in the contents of the elements in the tissues of these grasses.

Observations in 1988 and 1989 showed that the most persistent species on the refertilized plots were Canada bluegrass and Jamestown chewings fescue (Fig. 1). Canada bluegrass benefited significantly from refertilization through 1988, and the advantage persisted on a par with Jamestown chewings fescue, which had a good stand of grass even without refertilization. In 1989 the vegetative cover rating for Canada bluegrass was the same for both fertilizer treatments and was greater than any other species except Jamestown chewings fescue. Jamestown chewings fescue cover was not improved significantly by refertilization (Fig. 1). This species maintained high ratings throughout the first three years of the study but declined during 1989.

Colonial bentgrass persisted in the plots over the initial two years, and its performance ratings were the best of the grasses on the refertilized plots in 1986 and 1987 (Fig. 1). After 1987, performance declined and no benefit was realized from refertilization. Vegetative cover ratings of all species tested in this study other than Canada bluegrass, Jamestown chewings fescue and colonial bentgrass declined after 1986. The decline was less dramatic when refertilization was practiced. K-31 tall fescue and the Kentucky bluegrasses exhibited increased persistence for up to two years after refertilization. After four years, only Canada bluegrass and Jamestown chewings fescue had ratings greater than 2.0, regardless of fertilizer treatment.

For three species (tall fescue, Kentucky bluegrass and perennial rye), standard or common types were compared to improved turf-type cultivars. Since ratings in the non-refertilized plots were never greater than 5.0 after 1986 and were very low in 1989, none of these six grasses can be recommended for long-term cover at sites having these soil conditions. Significant differences were found among the varieties of tall fescue and perennial rye when they were refertilized. Palmer, a recently developed turf-type variety of perennial rye, had higher ratings than Linn, the common variety, up through 1987, but ratings for the two varieties were not significantly different in 1988 and 1989. For the tall fescues the reverse was true, with the older variety (K-31) recording higher ratings when refertilized than its more recent counterpart (Rebel).

Visual analysis of the grasses and the surround-

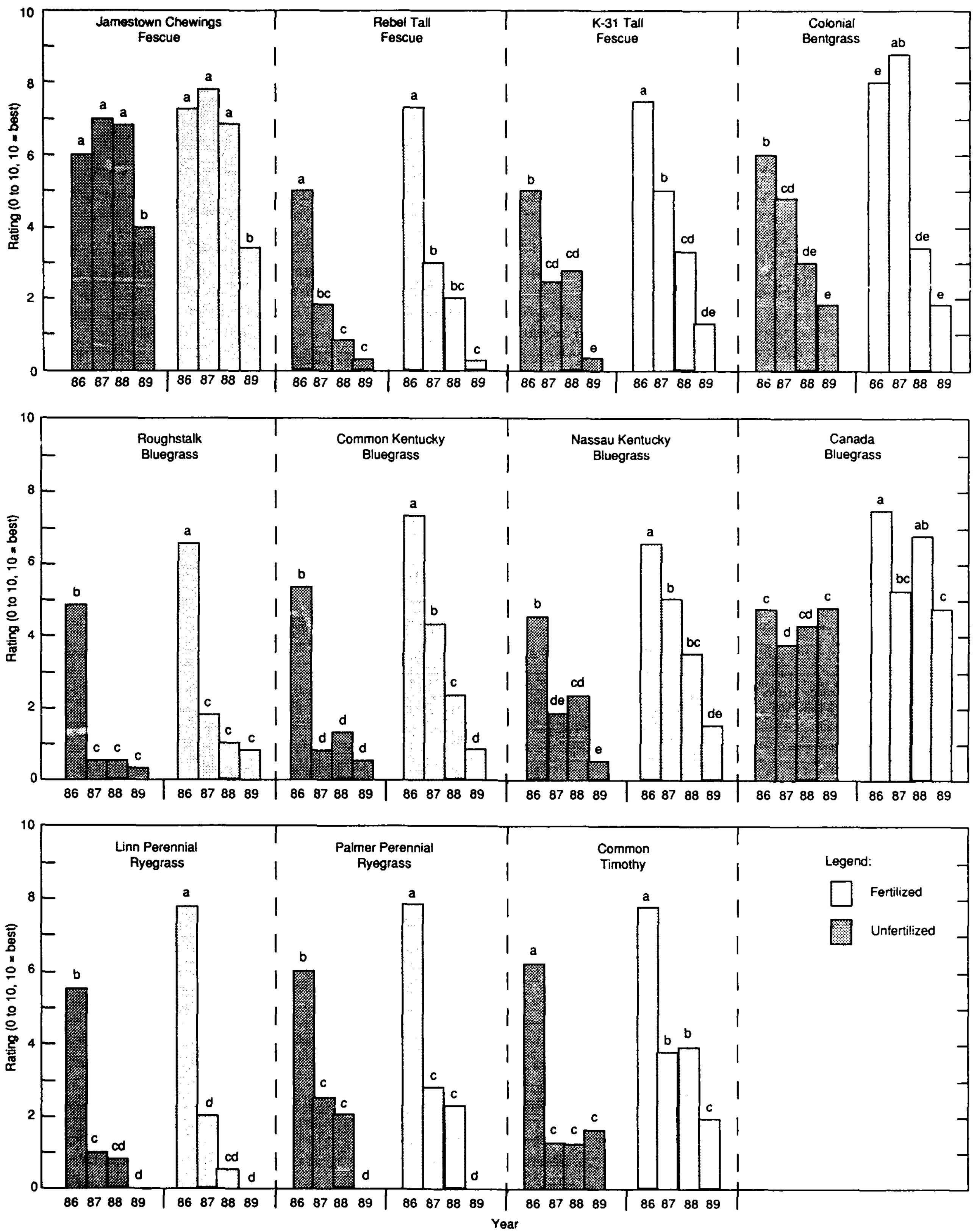

Figure 1. Vegetative ratings of sown cover. Ratings are on a 0–10 basis, with 10 being best and providing 100% soil cover. Means within rows of individual species and varieties followed by the same letter are not significantly different at the 0.05 level of probability.

ing native vegetation showed that the vegetation suffered from water stress during the warm summer months. This is understandable since the site was located on an elevated plateau of fill material with a very low water-holding capacity.

DISCUSSION

The differences in persistence among the 11 grasses studied appeared to be directly related to the low moisture- and nutrient-holding capacities of the fill soils they were growing on. The most persistent species were found to be Canada bluegrass and Jamestown chewings fescue. These species had the highest cover ratings and did not require refertilization a year after seeding to persist on this site. All other species required refertilization to improve rating scores over at least part of the next three seasons.

The success of Jamestown chewings fescue, a fine-leaf fescue, in other substrates has been reported by Hopkins and Green (1979) in grass swards, Palazzo (1983) on acidic soils and Wakefield et al. (1974) on roadsides. Gaffney and Dickerson (1987) stated that sheeps fescue (*Festuca ovina* L.), another fine-leaf fescue, was the best performer of six cool-season grasses tested on gravel mine sites.

The literature reports mixed success with Canada bluegrass. Wakefield et al. (1974) reported that it had poor performance in their studies. In contrast, Beard (1973) reported that this species tolerates well-drained sandy soils.

Refertilization, in general, tended to increase the persistence of the tolerant species (Canada bluegrass, Jamestown chewings fescue and Colonial bentgrass) for two to three years. With the less tolerant species, increased persistence was essentially limited to the growing season following refertilization. After four years there were no differences in the persistence of all species, whether or not they were refertilized after seeding. The need for nitrogen to maintain plant growth has been cited by Bloomfield et al. (1982). They reported that after-care is necessary for a minimum of five years to build up enough nutrient supply to produce a self-sustaining soil–plant ecosystem.

The results of this study showed that when seeded in the fall, Jamestown chewings fescue and Canada bluegrass were the best performers of the cool-season grasses grown on soil with low moisture- and nutrient-holding capacities in a cool, humid climate. Canada bluegrass also allowed the invasion of native species into its stand. When refertilization is practiced, seed mixtures may also include one of the two varieties of tall fescue and Kentucky bluegrass studied. Without refertilization, grass persistence declined. The perennial ryegrasses established plant stands quicker than any of the other species tested. This is well known. Although perennial ryegrasses do not persist in droughty soils, Wakefield et al. (1974) and Bradshaw and Chadwick (1980) recommended that they be included in seed mixtures because their rapid emergence and fast development provide early protection against soil erosion.

LITERATURE CITED

Beard, J.B. (1973) *Turfgrass: Science and Culture.* Englewood Cliffs, N.J.: Prentice-Hall.

Bloomfield, H.E., J.F. Handley and A.D. Bradshaw (1982) Nutrient deficiencies and the aftercase of reclaimed derelict land. *Journal of Applied Ecology,* **92**:151–158.

Bradshaw, A.D. and M. J. Chadwick (1980) *The Restoration of Land.* Los Angeles: University of California Press.

Carlson, W.W., D.L. Grunes, J. Alesi and G.A. Reichman (1961) Corn growth on Gardena surface and subsoil as affected by applications of fertilizer and manure. *Soil Science Society of America Proceedings,* **25**: 44–47.

Gaffney, F.B. and J.A. Dickerson (1987) Species selection for revegetating sand and gravel mines in the northeast. *Journal of Soil and Water Conservation,* **42**: 358–361.

Gardner, W.H. (1986) Water content. In *Methods of Soil Analysis. Part I. Physical and Mineralogical Methods* (A. Klute, Ed.). Madison, Wisconsin: American Society of Agronomy.

Hansen, J.E. and J.E. Mitchel (1978) The role of terraces and soil amendments in revegetating steep, smelter affected land. *Reclamation Review,* **1**: 103–112.

Hopkins, A. and J. O. Green (1979) The effect of soil fertility and drainage on sward changes. In *Changes in Sward Composition and Productivity.* British Grassland Society, p. 115–129.

Liegel, E.A. and E.E. Schulte (1977) Wisconsin soil testing and plant analysis procedures. Department of Soil Science, University of Wisconsin, Madison.

Michigan State University (1987) MSTAT (Version 4.0) Statistical Program. East Lansing, Michigan.

Martin, W.E. and J.E. Matocha (1973) Plant analysis as an aid in the fertilization of forage crops. In *Soil Testing and Plant Analysis.* Madison, Wisconsin: Soil Science Society of America, p. 393–426.

Palazzo, A.J. (1983) Long-term plant persistence and restoration of acidic dredge soils with sewage sludge and lime. USA Cold Regions Research and Engineering Laboratory, CRREL Report 83-28.

Palazzo, A.J. and J.M. Graham (1981) Plant growth studies on a gravel soil; Greenhouse studies. USA Cold Regions Research and Engineering Laboratory, Special Report 81-4.

Palazzo, A.J., S.D. Rindge and D.A. Gaskin (1980) Revegetation of two construction sites in New Hampshire and Alaska. USA Cold Regions Research and Engineering Laboratory, CRREL Report 80-3.

Paone, J., P. Struthers and W. Johnson (1978) Extent of disturbed lands and major reclamation problems in the United States. In *Reclamation of Drastically Disturbed Lands* (F. Schaller and R. Sutton, Ed.). Madison, Wisconsin: American Society of Agronomy.

U.S. Dept. of Agriculture–Soil Conservation Service (1980) A guide to conservation plantings in critical erosion areas. Syracuse, N.Y.

Wakefield, R.C., R.S. Bell, J.A. Jagschitz, A.J. Clapham, A.J. Dore, A.P. Nielsen and B.C. Laskey (1974) Establishment of roadside vegetation in Rhode Island. Agricultural Experiment Station Bulletin 416, University of Rhode Island, Kingston.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
June 1993

3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE
Selection of Cool-Season Grasses for Revegetating Well-Drained Fill Materials

5. FUNDING NUMBERS

6. AUTHORS
Antonio J. Palazzo

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Cold Regions Research and Engineering Laboratory
72 Lyme Road
Hanover, New Hampshire 03755-1290

8. PERFORMING ORGANIZATION REPORT NUMBER
Special Report 93-13

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Engineering and Housing Support Center
Ft. Belvoir, Virginia

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

Available from NTIS, Springfield, Virginia 22161.

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)

The objective of this study was to evaluate the performance and persistence of 11 cool-season grasses growing in well-drained fill materials. Grasses were evaluated over a four-year period and grown on fill material containing 11% gravel, 61% sand, 27% silt and 1% clay at the Franklin Falls Dam in Franklin, N.H. During the second season, half of each plot was refertilized. Visual observations of the sown grasses suggested that moisture stress was an important factor limiting growth. During the last two years of study, the most persistent species were Jamestown chewings fescue (*Festuca rubra* L. ssp. *commutata* Gaud.) and Canada bluegrass (*Poa compressa* L.). Refertilization helped to promote growth and increase persistence of all the sown species except for Jamestown chewings fescue. Three improved varieties of the grasses were not consistently more persistent than their common counterparts. This study demonstrates that there are major differences among cool-season grasses in their ability to tolerate well-drained, low-maintenance sites. When refertilized, varieties of tall fescue (*Festuca arundinacea* Schreb.) and Kentucky bluegrass (*Poa pratensis* L.) were more persistent, and a perennial ryegrass (*Lolium perenne* L.) provided rapid emergence.

14. SUBJECT TERMS
Fill materials Grasses Revegetation

15. NUMBER OF PAGES
10

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL